OPTIMIZING AIRCRAFT UTILIZATION FOR RETROGRADE OPERATIONS

GRADUATE RESEARCH PROJECT

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Abstract

U.S. Transportation Command (USTRANSCOM), the Department of Defense's (DOD) Distribution Process Owner (DPO), coordinates the movement of cargo to and from the Afghanistan and Iraq Areas of Operations (AORs). It attempts to optimize movement through the use of airlift, rail, trucking, and sealift while balancing cost and timeline requirements. Past Government Accounting Office (GAO) studies have found underutilization of airlift capacity as an area to gain more value in the movement of cargo, especially opportune cargo. This research attempts to determine the current utilization rate of airlift departing the AORs and the decision points for using sealift over available airlift capacity.

All C-17 and C-5 flights departing the AOR were analyzed to determine utilization rates with regards to capacity. Then, the additional costs of utilizing this capacity were determined as compared to sealift options to derive decision points.

The results show a continued underutilization of airlift capacity on C-17 and C-5 aircraft departing the AOR. However, when time is not a critical factor, the carrying costs involved in loading the additional cargo on these flights is often counterproductive to reducing the overall transportation cost. Recommendations were made on the appropriate weights to carry on these flights to optimize transportation costs.

To my wife, son, and daughter and also my parents.

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Joel E. Eppley

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Glossary

ACARS – Aircraft Communications and Reporting System
ACL – Allowable Cabin Load
AFB – Air Force Base
AIREVAC – Air Evacuation
AMC – Air Mobility Command
AMCI – Air Mobility Command Instruction
AOR – Area of Operations
APOD – Aerial Port of Debarkation
APOE – Aerial Port of Embarkation
CONUS – Continental United States
DOD – Department of Defense
DPO – Distribution Process Owner
DTR – Defense Transportation Regulation
GAO – Government Accounting Office
GATES – Global Air Transportation Execution System
GDSS – Global Decision Support Systems
GEMS – GATES Enterprise Management Service
ICAO – International Civil Aviation Organization
MAC – Military Airlift Command
MDS – Model Design Series (Type of Aircraft)
MRAP – Mine Resistant Ambush Protected
MTON – Measurement Ton
O&M – Operations & Maintenance
SAAM – Special Assignment Airlift Mission
SDDC – Surface Deployment and Distribution Center
TEU – Twenty-foot Equivalent Unit
TP – Transportation Priority
TWCF – Transportation Working Capital Fund
USTRANSCOM – United States Transportation Command

OPTIMIZING AIRCRAFT UTILIZATION FOR RETROGRADE

I. Introduction

Background

Optimum utilization of transportation resources is a major factor in cost control for most companies when studying their supply chains. It becomes even more critical when the company owns a significant portion of its transportation resources. This is the case for United States Transportation Command (USTRANSCOM) as it directs its subordinate commands, Air Mobility Command (AMC), Military Sealift Command (MSC), and Military Surface Deployment and Distribution Center (SDDC), in a fiscally constrained environment. In 2003, USTRANSCOM was named the Department of Defense (DOD) logistics distribution process owner (DPO) and given the mission to "improve the overall efficiency and interoperability of DOD distribution related activities - deployment, sustainment, and redeployment support during peace and war" (TCJ5/4-S, 25 Aug 10). The search for efficiency is even more critical considering "freight traffic is expected to at least double over the next 20 to 30 years" (Edmonson, 2009), which may limit the availability of unused commercial cargo capacity and force the DOD to maximize the use of its own assets.

It is not hard to find inefficiency in the DOD, especially when considering examples from the commercial industry. In the commercial transportation industry, empty backhauls represent inefficiency and are a significant resource drain, especially considering the effects of higher fuel charges and driver shortages. Coyle et al. (2011)

contend commercial carriers will often adopt a loss minimization strategy. This occurs when the market will not support the price to recoup the carrier's full marginal costs. Thus, rather than returning empty and incurring a total loss, the carrier lowers prices in accordance with market demands to minimize its losses. The other way carriers may choose to look at backhaul efficiency is by considering wages and fuel as a fixed cost and shipment loading and reduced fuel efficiency as the marginal cost. Now, the backhaul price charged contributes to the average fixed cost and the marginal cost with the overage being considered a profit.

For the DOD as a whole, the solution becomes much more complicated when considering a full spectrum multi-modal solution versus exclusively a truck, rail, sea, or air option. The USTRANSCOM Fusion Cell, formed in 2007, attempts to provide an optimized multi-modal solution by "collaborating earlier in the decision cycles; developing enterprise wide, executable plans; monitoring end-to-end movement of forces and sustainment; and providing agile, adaptive logistics solutions in support of the warfighter" (Johnson, 2011). If each portion of the DOD were able to look out purely for their needs, the inefficiency in the system would most assuredly increase. However, with entities like the Fusion Center validating movements, the enterprise as a whole is at least attempting to find efficiencies.

Problem Statement

Flying airplanes empty or nearly empty passes few people's common sense test. In the case of AMC, the A9 staff believes much of its organic C-5 and C-17 fleet flies back from the Middle East to the continental United States (CONUS) empty or nearly

empty (Anderson, 2011). The purpose of this research is to evaluate another "distribution initiative(s) with the underlying goal(s) of improving velocity, precision, visibility, and efficiency" (McNabb, 17 Dec 08). In this case, the research will determine the historical utilization of airlift for retrograde operations and the effects on the inter-theater airlift system if any additional cargo hauling capacity is utilized on depositioning C-5 and C-17 assets. With the redeployment of forces from Afghanistan and Iraq already under way and considering AMC will continue to fly Special Assignment Airlift Mission (SAAM) and Contingency categorized missions in the future, maximizing cost efficiency of all available assets is essential, if the DOD is to be good stewards of the government's resources.

Research Objectives

While focusing on fully evaluating the effective use of organic theater airlift, this paper has 4 main objectives.

Objective 1: Determine the amount of available airlift flowing back to CONUS from Afghanistan and Iraq.

Objective 2: Compare the cost of flying C-17s and C-5s back to CONUS empty vs. flying them back with full cargo loads.

Objective 3: Compare the increased cost of fully laden C-17s and C-5s to the cost of using sealift to ship cargo to CONUS.

Objective 4: Deliver to USTRANSCOM and AMC leadership a method for determining the cost and benefit of utilizing excess cargo capacity flowing back to the CONUS.

Research Focus

Methodology

To determine the amount of available airlift flowing back to the CONUS and the amount of cargo being carried on those aircraft, data will be extracted from the Global Air Transportation Execution System (GATES) for cargo operations between May 2010 and May 2011. This data will be filtered to include only C-5 and C-17 aircraft departing airfields in Afghanistan and Iraq for destinations outside of those areas on their way back to the CONUS. Averaging the amount of cargo being hauled on the initial leg out of Afghanistan and Iraq will provide a baseline for comparing the actual cargo load versus the standard planning load for each airframe.

To meet the last three objectives, a network model was considered. However, "The golden rule is not to build a complicated model when a simple one will suffice." (Deboys, 2004, 85). Too often, complicated modeling techniques are relied upon to provide a robust solution when simple analysis with acceptable assumptions is able to provide a model that is easily adjusted for future uses. Therefore, after determining standard flight route distances from Afghanistan and Iraq and cost-to-carry penalties for each airframe, the cost of flying empty versus fully laden C-5 and C-17 aircraft will be determined. These values will then be compared to standard sealift shipping charges and

framed into a method for determining if and when cost-to-carry penalties make sealift a more affordable option.

Assumptions/Limitations

When computing trends and costs, it is important to consider the total scope and limit of the variable values. To simplify the analysis and make these computations possible, some assumptions/limitations will be applied to the analysis:

Assumption 1: While volume is a factor for cargo shipments, for this project, the cargo or payload will be considered purely based on its weight, as the effort to the move the weight is the same no matter if it is passengers or bulk or liquid cargo.

Assumption 2: Price per gallon of fuel will be fixed at $3.95 per gallon.

Assumption 3: There is cargo available at all departure locations.

Assumption 4: Aircraft and sealift support costs, while part of the movement, will not be factored into the total cost of operating these assets.

Assumption 6: Global Decision Support Systems (GDSS) and GATES data will be considered accurate and represent a relative sample for all retrograde movements from the theater.

Assumption 7: Air refueling assets will not be utilized to extend aircraft range.

Assumption 8: All considered airlift and sealift assets of the same type will all perform the same, regardless of manufacturing year, historical hours of usage, etc.

Implications

While this research is targeted for use by USTRANSCOM, it potentially has application outside of just the DOD, as many transportation companies are in the business of multi-modal operations, especially considering "freight traffic is expected to at least double over the next 20 to 30 years" (Edmonson, 2009).

II. Literature Review

Chapter Overview

The objective of this literature review is to provide the background necessary to guide the remainder of this research effort. The chapter will be broken into four parts. Part one will examine literature describing the DOD's historical cargo capacity usage and the steps taken to try and improve the effective use of unused space. Part two will explore how aircraft allowable cabin load is used to determine the amount of capacity available. Next, parts three and four will discuss the establishment of airlift and sealift rates, respectively, and how they apply to DOD shipments. An understanding of these areas is essential in analyzing the potential impact of maximizing military cargo capacity.

Historical Utilization

To improve space utilization and reduce empty backhauls on flights, Military Airlift Command (MAC) established Transportation Priority-4 (TP-4) air freight service.

In the late 1960s, DOD initiated a cargo program, later dubbed TP-4 cargo, to maximize unused cargo capacity on military flights returning to the United States from overseas and then expanded the program in 1984 to include outbound cargo from the continental United States moving overseas (GAO, 1992). "TP-4 rates are developed for uniquely identifiable commodities that do not create an additional wartime movement dependency on airlift when moved in peacetime using excess by-product capability" (AMCI 24-101V1, 2006, 6). However, for the Air Force, empty or underutilized backhauls have been an issue since at least October 1973 when the DOD sent a letter to the military services reiterating its policy on the use of Military Airlift Command, the predecessor the AMC, airlift for the movement of unaccompanied baggage shipments and household goods and again in May 1976 concerning general cargo (GAO, 1983).

Despite these efforts, a Government Accounting Office (GAO) study (1983) conducted on space utilization of MAC aircraft from October 1980 to March 1982 concluded aircraft were still being utilized, based upon cargo weight capacity, at 65% for transatlantic and 50% for transpacific flights. The study suggested to Secretary of Defense Caspar Weinberger, if cargo being moved by commercial ocean carriers was placed on these MAC flights, the result would be $3.4 million in cost savings. While the DOD disagreed with the way the unused cargo capacity was calculated, particularly since it did not take into account space required to move bulk cargo that may not utilize the full cargo weight carrying capacity of the aircraft, it did concede "that both MAC and the services can take actions to optimize current levels of use" (GAO, 1983).

The issue reemerged again when another GAO study (1992) concluded the Air Force continued to operate with substantial amounts of unfilled capacity. It concluded in 1988 and 1989 that the cargo capacity, again based on weight, was only being utilized to 62% of capacity and estimated on average of 64% for 1992, which could result in a reduction of $21 million per year in DOD's overall transportation costs if the full capacity was utilized. The study cited issues with the way AMC calculates cargo allocations for the TP-4 program by only offering one-half of its historical unused cargo allocation. This results in less low priority cargo being on hand at aerial port terminals to be able to fill the aircraft.

AMCI 24-101V1 (2006) further restricts movement of cargo in the TP-4 system by not allowing cargo defined as TP-1 or TP-2 to be categorized as TP-4 cargo. TP-4 cargo can only be held for 20 days before it is considered frustrated and aerial port officers are required to divert the cargo to other transportation modes. Further, "during contingencies and peak workload periods, the air freight officer/superintendent will close the port to TP-4 cargo, as necessary, to ensure higher priority, air eligible cargo movement is not delayed" (AMCI 24-101V1, 2006, 7). Further, while AMCI 24-101V9 instructs load planners to "maximize payload up to the constraint of the Allowable Cabin Load (ACL) for each segment of the flight," it also place restrictions. Specifically instructing 618 TACC flight managers to only give Hickam, McChord, Travis, Charleston, Dover, and Ramstein missions maximum ACL for aircraft flying on active legs (i.e. not providing maximum ACLs for positioning/depositioning missions). These are just a few of the restrictions making it difficult for aerial ports, already strained through their support of

contingency operations around the world (Iraq, Afghanistan, Libya, Horn of Africa, etc.), to focus efforts on maximizing cargo capacity.

In 2011, AMC continues to be concerned with underutilization of aircraft. AMC's A9 staff believes much of its C-5 and C-17 fleet flies back from the Middle East to the continental United States (CONUS) empty or nearly empty (Anderson, 2011). Therefore, for AMC, it is essential to evaluate the current intertheater cargo usage of C-5 and C-17 aircraft and determine the cargo loads necessary to maximize the cost benefits in the utilization of these aircraft in the redeployment of warfighting personnel and equipment from the Middle East to CONUS. However, sister services may look at the Air Force's charged rates and schedule and decide on a commercial option, especially when operating in a wartime environment where supplemental funding above their normal resources allows them to spend more freely. Thus, the potential empty backhaul for the Air Force represents significant supply chain inefficiency.

With budget cuts looming and an ever increasing deficit, the DOD is challenged more today than ever to be good stewards of the government's resources. Maximizing efficiency and effectiveness of all DOD assets is just one of many initiatives that must be continuously addressed to meet warfighter needs and taxpayer expectations.

Aircraft Allowable Cabin Load

To maximize aircraft use, it is important to know the capabilities of the assets being studied. For airlift assets, this project focuses on the C-5 and C-17. Each of these aircraft can be configured to carry combinations of cargo (palletized and rolling stock)

and passengers. The configuration determines the amount of capacity available. However, capacity is not the only determinate of the aircraft's ability to haul cargo and passengers. The total weight and placement of the load is also very important, as each aircraft has an allowable cabin load.

ACL is "the maximum payload that can be carried on a mission…may be limited by the maximum takeoff gross weight, maximum landing gross weight, or by the maximum zero fuel weight" (AFPAM 10-1403, 2003, 24). Maximum takeoff gross weight and landing gross weight are the weight limits with which an aircraft can takeoff and land. Maximum zero fuel weight is the weight limit with which an aircraft may be loaded without including the weight of the fuel. ACL may vary based on the type of mission, destination, distance, weather, operational priorities, airfield conditions, and the aircraft characteristics. Finally, maximum payload may also be expanded in wartime situations. For future computations, the author will utilize the peacetime planning ACL. Table 1 summarizes the ACLs for the C-5 and C-17, as obtained from the Defense Transportation Regulation (DTR) Part III Appendix V.

Table 1: Allowable Cabin Loads for the C-5 and C-17

Aircraft Type	Peacetime Planning ACL (lbs)	Wartime Planning ACL (lbs)
C-5	150,000	175,000
C-17	90,000	107,900

Airlift Rates

For AMC and air specific services, "airlift services furnished to authorized customers are chargeable to DOD funds, other federal funds, or allied air forces when a cooperative military airlift agreement exists" (AMCI 65-602, 2009, 8). These services are charged based on tariff rates that are developed by USTRANSCOM and approved by the Office of the Undersecretary of Defense (Comptroller) through the President's Budget Cycle. These funds all circulate within the DOD's budget as a whole. Thus, while AMC could potentially charge higher tariffs to make a larger profit for itself, it would not be the optimal solution for the DOD.

The optimal DOD solution involves maximizing asset utilization and efficiency while keeping tariff rates competitive to commercial industry. Tariff rates will remain competitive because "Transportation Working Capital Fund (TWCF) channel passenger and cargo tariff rates are set annually based on commercial competition or a standard rate per mile. As a result, they do not recover full costs due to AMC's requirement to maintain the wartime capacity of the airlift system. The difference between the revenue that TWCF receives and costs incurred for these airlift services is offset by an Air Force O&M-funded Readiness Account" (AMCI 65-602, 2009, 8). Therefore, for AMC, less-than-full aircraft represent a significant issue and is a target for efficiency.

To determine the rate structure within the DOD, one must first understand USTRANSCOM generally fulfills airlift requirements through regular scheduled missions across fixed routes, also known as channel missions. Channel missions may be

further categorized as frequency based or requirements based. Movements on these types of missions are billed on a per pound basis based on cargo zones (see Appendix A and B for the zone designations and FY12 zone rates). Specifically, according to the USTRANSCOM TWCF Rate Procedures for FY12:

> AMC bills on a per pound basis. The Office of Under Secretary of Defense Comptroller, OUSD(C), directs AMC cargo rates be commercially comparable. Each country is assigned to a regional zone and rates are benchmarked to commercial tenders or historical commercial shipping data. The following rules were used:
>
> a. Rates are priced $0.01 per pound lower than existing commercial competition (commercial tenders).
>
> b. Rates vary by weight break (1-439; 440-1099; 1100-2199; 2200-3599; 3600+).
>
> c. There is a $1 per pound minimum rate for all routes to help recover fixed costs. There is also a minimum shipment weight billed of 10 pounds per cubic foot and a minimum charge of $25 per shipment to recover fixed costs.

However, there are missions that fall outside of normal channel requirements. These are categorized by SAAM or Contingency mission types, which are similar to aircraft charters. Specifically, SAAM missions are "unique airlift customer designated missions to move special requirements or fly to locations that are not normal channel stops" (AMCI 65-602, 2009, 29). Contingency missions are "airlift missions in direct support of humanitarian, natural disaster, and other emergency requirements, and Operation Plans or non-exercise Operation Orders" (AMCI 65-602, 2009, 30). When a unit needs to move outside of the normal channel schedule, they must charter AMC through USTRANSCOM.

There are significant differences when looking at Channel versus SAAM / Contingency other than just scheduling, notably pricing, how hours are computed, and what happens with unused capacity. While Channel rates are charged by pound, SAAM /

Contingency missions are charged by multiplying the actual number of flying hours used to perform the mission by the applicable rate for the type of aircraft used. Effective October 1, 2011 through September 30, 2012, for the C-5, the rate is $29,099 per hour with a minimum activity rate of $58,198. For the C-17, the rate is $13,280 per hour with a minimum activity rate of $53,120.

Next, one must understand how the number of chargeable hours is computed. For SAAM missions, "the number of chargeable hours includes the time from the departure of the aircraft performing the mission to the positioning point, to each customer directed stop, and to the depositioning point" (Skoog, 2011, 1). The charges for positioning and depositioning include departing from and returning to the home station of the aircraft tasked, unless the aircraft is in-system selected to accomplish another mission. Similarly, contingency missions are billed by "the total hours flown for organic airlift missions to include all legs of the mission: positioning, active, divert (maintenance or weather), and depositioning" (Skoog, 2001, 5).

Finally, with regard to the differences between Channel and SAAM / Contingency charges, AMC reserves the right to use any unused capacity to move cargo at the opportune rate. This is similar to practices in the commercial industry where any unused capacity is sold to customers to produce as much revenue as possible for the carrier. Since the aircraft must already travel the designated route, capacity is considered perishable and should be sold or lost forever. Further, most of the fixed and variable costs will have already been absorbed by the original charter, so the costs to fly the additional payload is significantly less.

Just consider how hotels use sites like Hotels.com to sell unsold rooms. While rooms are discounted from the standard rate, they produce more revenue than an empty room. For AMC, the opportune cargo would fly at the current channel tariff rate for the cargo and passengers moved and generate additional revenue (AMCI 65-602, 2009, 29) for the command and more movement of cargo for its customers. For the purposes of this project, unused capacity will be charged at the Zone 9 to Zone 1 channel rates listed in Appendix B.

Sealift Rates

With an understanding of how units are charged to move their cargo by air, it is now important to evaluate the efficient use of sealift. For the movement of a large amount of dense cargo, it is assuredly cheaper and very often faster to transport it by sea than air. However, in general, airlift is faster, requires less packaging, and reduces warehousing and stock-out costs. It also reduces inventory carrying costs, such as reduction of pilferage, breakage, or deterioration, reduced insurance rates, and requires less inventory throughout the system. Further, for high profitability cargo, the use of airlift allows the cargo to move faster while not adding significantly to its overall price. For the DOD, it is most often about the speed of airlift over sealift.

The DOD witnessed the advantages of sealift firsthand when it was looking to transport thousands of Mine Resistant Ambush Protected (MRAP) vehicles between 2010 and 2011. It was estimated the cost of shipping one MRAP by sea was $18,000 versus

$135,000 by air (Thuermer, 2012). Specifically, the USTRANSCOM 2011 Annual Report points out:

> "Through multi-modal operations, we moved large volumes of cargo and thousands of vehicles by sea to locations in closer proximity to the U.S. Central Command area of operations, by truck from the seaports to the nearby airfields and then by air to Afghanistan. This concept was used with great success throughout 2010 and 2011 as we moved over 4,200 of 7,000 Mine Resistant Ambush Protected all-terrain vehicles to Afghanistan via multi-modal. Employing the combination of air, land, and sea modes of transportation resulted in increased velocity, better utilization of aircraft, and ultimately reduced costs by almost $85 million in fiscal year 2011 and $485 million since April 2010 when multi-modal operations for these vehicles began."

Further, the MRAPs were also delivered much faster via this multi-modal operation than with an airlift only movement. General Johns (AMC Commander) pointed this out in 2011 during an interview with the Defense Writers Group:

> "When we first started flying MRAPs in we would take over a C-17 with three MRAPs on it. It would air refuel, and then land at Ramstein, turn then go into the Area of Operations (AOR). And those three MRAPs were a 20 hour flight. It was terribly effective to get those as soon as we could to those that needed them. We brought them in.
>
> Then TRANSCOM, the air component, said hey, what if we filled a ship and that ship traverses over and we go into the AOR near it with 250, 300, 400 MRAPs/MATVs on it? Then basically, once you load that pipeline, as that ship offloads I start shoveling C-17s in and out with three to five on them. By doing that, we actually save $110 per 1,000 MATVs or MRAPs. Huge. And yet once that sea pipeline is full I never run out of cargo so the C-17s stay busy. So it's wonderfully effective when we use multi-modal. We save a lot of money plus I get a lot more to the warfighter quicker."

The low transportation costs associated with sealift is what gives it an edge. The DOD figures transportation costs by zone where sealift cargo is moved on scheduled commercial liner service and charged based on the traffic area code pairs being serviced, regardless of the direction of the cargo movement. Liner service is scheduled by the

Military Surface Deployment and Distribution Command, a component of USTRANSCOM. Only in rare cases will a unit be charged a different rate. For the purposes of this project, the stabilized billing rates for general containers listed in column CC-13 of Appendix C will be used.

The container rates in Appendix C are normally all inclusive and include the costs associated with door-to-door movement of the container from its inland point of origin to its final inland destination. The rates are billed in measurement tons (MTONs). A measurement ton is equivalent to 40 cubic feet. According to SR International Logistics, the standard twenty-foot container, commonly referred to as a twenty-foot equivalent unit (TEU), has a capacity of 1,172 cubic feet and a maximum cargo capacity of 47,900 pounds. This means there are approximately 29.3 MTONs in a TEU (1,172 ft^3/40 ft^3), a value that will be utilized in later calculations. With an understanding of the benefits of sealift and how it is charged, it must now be determined when are the appropriate times to use it.

Summary

This chapter built the foundation from which to continue this research effort. Part one explored the historical use of airlift capacity, and the GAO's reports on the DOD's continued inability to utilize its unused space. Part two explained how aircraft cabin load is used to establish the planning capacity for aircraft. Next, part three discussed the establishment of airlift rates and how they could be applied to opportune cargo shipments. Finally, part four provided background on sealift rates and how units are

charged for commercial liner container traffic. This research will now explore how the DOD has performed recently on utilizing capacity and what the impacts to the consumer will be if shipments currently moved by air are transferred to sea.

III. Methodology

Chapter Overview

The goal of this chapter is to provide a detailed account of the methodology used in this research effort. This chapter begins with an explanation of the breakdown of the data from GDSS and GATES used in the research. Data was provided from November 2009 to October 2011 for GDSS and from May 2010 to May 2011 for GATES. The data is refined to determine the average intertheater airlift utilization for aircraft departing Afghanistan and Iraq.   Finally, a simple network analysis is performed to determine the difference in costs of moving retrograde cargo on airlift versus sealift.

GDSS Data

The GDSS data for this part of the analysis was provided by AMC/A9 for the period from November 2009 to October 2011. Cargo and passenger data was extracted for every mission contained within the database during this period. Each line of data extracted provides detailed information for every mission during this period, including number of passengers, baggage weight, departure and arrival International Civil Aviation Organization (ICAO) designation, and much more. To simplify the data, the following columns were deleted as extraneous or blank:

- DEP_ICAO_ID – extraneous, as data retained in DEP_ICAO.

- DEP_COUNTRY_ID – extraneous, as data retained in DEP_ICAO where all "OA" ICAO represent Afghanistan and all "OR" ICAO represent Iraq.

- DEP_COUNTRY_NAME – extraneous, as data retained in DEP_ICAO where all "OA" ICAO represent Afghanistan and all "OR" ICAO represent Iraq.

- DEP_THEATER_NAME – extraneous, as theater name not additive in analysis process.

- ARV_COUNTRY_ID – extraneous, as data retained in ARR_ICAO.

- ARV_THEATER_NAME – extraneous as theater name not additive in analysis process.

- SCH_TAKEOFF_DATE_TIME – extraneous, as study is about capacity usage and not departure reliability.

- SCH_LANDING_DATE_TIME – extraneous, as study is about capacity usage and not departure reliability.

- AIRCRAFT_ACL_GATES – deleted due to all fields being blank.

- PLAN_TAKEOFF_CG_FT – extraneous, as study is about capacity usage and not aircraft loading.

- SCH_GROUND_TIME – extraneous, as study is about capacity usage and not aircraft turn times.

- ACT_GROUND_TIME – extraneous, as study is about capacity usage and not aircraft turn times.

Table 2: Screenshot of GDSS data

SORTIE_ID	AM_ID	SORTIE_MISSION_ID	AMC_MISSION	MISSION_CLASS	MDS	TAIL_NUMBER	DEP_ICAO	ARV_ICAO	ARV_COUNTRY NAME	ACT_DEP DATE_TIME	ACT_ARV DATE_TIME	GREAT_CIRCLE MILES
1788600	2001101BL13201105249755	PLR05Y6XF155	TRUE	CHANNEL	C017A	21111A	OADY	ETAR	GERMANY	6/5/2011 2:07	6/5/2011 8:57	2739.64
425232	2001101BL12201006153506	JBRGFZ7XA169	TRUE	CHANNEL	C005A	90001B	OAIX	ETAR	GERMANY	6/18/2010 18:05	6/19/2010 1:20	2796.09

ACT_FLYING TIME	ROLL_STK_PALLET_EQUIV ABOARD_GATES	LOOSE_PALLET_EQUIV ABOARD_GATES	CARGO_PALLET EQUIV_ABOARD GATES	PAX_ABOARD BEST	ROLL_STK_WGT ABOARD_GATES	PALLETS_WGT ABOARD_GATES	LOOSE_WGT ABOARD_GATES	BAG_WGT ABOARD_GATES	CARGO_WGT ABOARD_TACC	CARGO_WGT ABOARD_GATES	CARGO_WGT ABOARD_BEST	POSITIONING	DEPOSITIONING
410	0	0	5	2	0	11580	0	44	8200	11580	11580	FALSE	FALSE
435	0	0	0	0	0	0	0		0	0	0	FALSE	FALSE

Table 2 shows a screenshot of the remaining data from GDSS available for analysis. To better understand the data, it is essential to understand each variable. The following is a brief explanation for each variable:

- SORTIE_ID: GDSS Sortie Identification number.
- AM_ID: Air Movement Identification number.
- SORTIE_MSN_ID: GDSS Mission Identification number.
- AMC_MISSION: Identifies if mission is attributed to AMC (TRUE or FALSE).
- MISSION_CLASS: Mission Classification (e.g. CHANNEL, CONTINGENCY, etc.).
- MDS: Model Design Series (i.e. aircraft type).
- TAIL_NUMBER: Aircraft Tail Number.
- DEP_ICAO: Departure International Civil Aviation Organization (ICAO) airport code.
- ARV_ICAO: Arrival ICAO airport code.
- ARV_COUNTRY_NAME: Arrival Country Name.
- ACT_DEP_DATE_TIME: Actual Departure Date and Time.
- ACT_ARR_DATE_TIME: Actual Arrival Date and Time.
- GREAT_CIRCLE_MILES: Distance flow in great circle miles, which is the shortest distance between the departure and arrival points.
- ACT_FLYING_TIME: Actual Flying Time.
- ROLL_STK_PALLET_EQUIV_ABOARD_GATES: Rolling Stock Pallet Equivalents loaded on the plane according to GATES.
- LOOSE_PALLET_EQUIV_ABOARD_GATES: Loose Pallet Equivalents loaded on the plane according to GATES.
- CARGO_PALLET_EQUIV_ABOARD_GATES: Cargo Pallet Equivalents loaded on the plane according to GATES.
- PAX_ABOARD_BEST: Passenger loaded on the plane .
- ROLL_STK_WGT_ABOARD_GATES: Rolling Stock Weight loaded on the plane according to GATES.

- PALLETS_WGT_ABOARD_GATES: Pallet Weight loaded on the plane according to GATES.
- LOOSE_WGT_ABOARD_GATES: Loose Weight loaded on the plane according to GATES.
- BAG_WGT_ABOARD_GATES: Baggage Weight loaded on the plane according to GATES.
- CARGO_WGT_ABOARD_TACC: Cargo Weight loaded on the plane according to TACC.
- CARGO_WGT_ABOARD_GATES: Cargo Weight loaded on the plane according to GATES.
- CARGO_WGT_ABOARD_BEST: Cargo Weight loaded on the plane according to the best data available.
- POSITIONING: Defines if the leg is a positioning leg (TRUE or FALSE).
- DEPOSITIONING: Defines if the leg is a depositioning leg (TRUE or FALSE).

GDSS Space Utilization

To evaluate the general utilization rate of C-5 and C-17 airlift around the world, the overall GDSS data is evaluated. First, sorties were eliminated where the departure ICAO (DEP_ICAO) and arrival ICAO (ARR_ICAO) were the same, as this would result in no meaningful transport of cargo. To do this, a column was added to compare the departure and arrival ICAOs using the formula =IF(M2=I2,0,1). If the airfields were the same, the formula places a zero in the field, and if they were not the same, it returns a one. All other sorties will be considered viable for use in moving cargo.

Next, the average utilization rate of the C-17 and C-5 on the remaining sorties must be determined. To do this, averages were taken of the best cargo weight data (CARGO_WT_ABOARD_BEST). However, some values in this column were blank. To allow Excel to average these sorties properly, a new column was added to insert zero

values for these sorties where the formula was =IF(A2="",0,A2). This would allow Excel to evaluate the CARGO_WT_ABOARD_BEST values. If it was blank, it would place a zero in the field. If it contained a weight, that weight was placed in the field. Using these values, the averages on each airframe were determined using the formula =AVERAGEIFS($AK$2:$AK$481966,$F$2:$F$481966,"C017*",$N$2:$N$481966,0). In this formula, it calculates the average of the column while filtering for only those with the C-17 as the MDS and sorties that depart and arrive at different locations. This resulted in the evaluation of 72,774 C-17 and 9,690 C-5 sorties. The data was then summarized in a table.

Next, to determine the utilization rate of cargo capacity as it pertains to aircraft departing Afghanistan and Iraq, the GDSS data must then be narrowed down, as the initial data pull from November 2009 to October 2011 resulted in 481,975 data points. This data included every mission departure from every station in the world. Therefore, to look at just the departures from Afghanistan and Iraq, the data was sorted by departure ICAO (DEP_ICAO), and all rows, except those pertaining to Iraq (OR**) and Afghanistan (OA**), were deleted. Next, there are many intratheater flights, which are not considered candidates for opportune cargo movement. To delete these intratheater flights, the data was sorted by arrival ICAO (ARR_ICAO), and all rows with Iraq (OR**) and Afghanistan (OA**) were deleted.

The data has now captured all flights departing Iraq and Afghanistan to destinations outside of these countries. However, the data must still be filtered to only include C-5 and C-17 aircraft, so the data was sorted by aircraft type (MDS), and all

rows, except C-17 (C017A) and C-5 (C005A, C005B, and C005M) flights, were deleted. Next, there were air evacuation (AIREVAC) missions that by nature are not designed to fully utilize the airplane, so the data was sorted by mission type (MISSION_TYPE) and all AIREVAC missions were eliminated.

The data has now been filtered sufficiently; however, a few steps were taken to prepare the data for easier manipulation. The data was re-sorted by departure ICAO (DEP_ICAO), and all remaining Iraq departures were moved to a separate worksheet, leaving the Afghanistan data on its own worksheet. With the multiple columns of weight data, it was decided to use the CARGO_WGT_ABOARD_BEST column to determine the average weight loaded on the aircraft. Some of the rows in this column were blank, which will invalidate standard Microsoft Excel average calculations. To remedy this, if all the other columns pertaining to the aircraft's cargo and passenger load were blank, the aircraft were assumed to be empty, and a new column was created to automatically enter a 0 for these empty aircraft vice having to enter the 0 value individually. This was done using the logic statement =IF(Y2="",0,Y2). Finally, this column of data was averaged by airframe using the formula =AVERAGEIF($F$2:$F$16641,"C005*",$Z$2:$Z$16641) for each country, and the averages were combined into a table. However, since not all command and control systems always integrate fully, the GATES data will be evaluated to see how it compares to the GDSS data analysis.

GATES Data

The GATES data for this research provided by AMC/A9 was from the period May 2010 to May 2011. Cargo and passenger data was extracted for every mission

contained with the database during this period. Each line of data extracted provides detailed information for every individual pallet and every passenger manifest, including pallet gross weight, the pallet's aerial port of embarkation (APOE) and debarkation (APOD), and much more. Table 3 shows a screenshot of the cargo data from GATES. To simplify the data, the time stamp columns for departure and arrival and the QTSeq column were deleted.

Table 3: Screenshot of GATES data

ATMS_ID	PAL_ID	PLT_GROSS_WT	APC	APOE_MSN_ID	APOE_LEG_ID	MNFST_APOD	APOD_MSN_ID	APOD_LEG	MDS	Tail_NUM	MSN_PRIOR	APOE_APC	APOD_APC
AU1101000141	OR9XZQ	4690	OR9	AAM101404287	200	HOP	AVM101404287	500	C005B	40061	1B1	OR9	HOP
AU1101000141	OR9YAZ	4150	OR9	AAM101404287	200	HOP	AVM101404287	500	C005B	40061	1B1	OR9	HOP
AU1101000141	OR9XVL	49055	OR9	AAM101404287	200	HOP	AVM101404287	500	C005B	40061	1B1	OR9	HOP

APOE_ICAO	APOD_ICAO	AIR_DIM_CD	AIR_CMDTY_CD	PAL_APOE	PAL_APOD	PLT_VOL	PLT_HT	PLT_NET_WT	PLT_PCS_QY	PLT_ULTMT_CNSGNE	PLT_TY_CD	PALLET_TYPE	MNFS_ID
ORBD	KHOP	D	V	OR9	SDF	512	93		1	Q99129	L	PC	00213
ORBD	KHOP	D	V	OR9	DOV	400	73		5	W25G1W	B	PC	00213
ORBD	KHOP	D	V	OR9	SDF	6808	150		1	Q99129	A	RS	00213

As before, to better understand the data, it is essential to understand each variable. The following is a definition for each variable, as defined by the GATES Enterprise Management Service (GEMS) Glossary (Wilson, 2011).

- <u>ATMS_ID:</u> Air Transportation Mission ID or Primary Mission Key.
- <u>PAL_ID:</u> Pallet Identification Number where first three-digits consist of an Aerial Port Code (APC) for the Aerial Port which built the pallet and the last three positions are alphanumeric characters representing a unique identifier.
- <u>PLT_GROSS_WT:</u> Pallet Gross Weight containing the combined weight of a pallet or container and its contents, including packaging material.
- <u>APC:</u> Aerial Port Code for where the pallet is currently located.
- <u>APOE_MSN_ID:</u> Aerial Port of Embarkation aircraft mission number.
- <u>APOE_LEG_ID:</u> Aerial Port of Embarkation aircraft leg ID (for internal tracking).
- <u>MNFST_APOD:</u> Manifest Aerial Port of Debarkation.

- APOD_MSN_ID: Aerial Port of Debarkation aircraft mission number.
- APOD_LEG: Aerial Port of Debarkation aircraft leg ID (for internal tracking).
- MDS: Model Design Series (i.e. aircraft type).
- TAIL_NUM: Aircraft Tail Number.
- MSN_PRIOR: Mission Priority.
- APOE_APC: Aerial Port of Embarkation Aerial Port Code.
- APOD_APC: Aerial Port of Debarkation Aerial Port Code.
- APOE_ICAO: Aerial Port of Embarkation departure airport ICAO code.
- AIR_DIM_CD: Air Dimension Code.
- AIR_CMDTY_CD: Air Commodity Code.
- PAL_APOE: The aerial port code which represents the embarkation point of the pallet.
- PAL_APOD: The aerial port code which represents the debarkation point of the pallet.
- PLT_VOL: The volume of the pallet in cubic feet. For mail pallets, the volume is set to zero.
- PLT_HT: The height of the pallet in inches.
- PLT_NET_WT: Net weight of the pallet in pounds.
- PLT_PCS_QY: Pallet Pieces Quantity.
- PLT_ULTMT_CNSGNE: Pallet Ultimate Consignee (i.e. customer ID number).
- PLT_TY_CD: Pallet Type Code, describing the specifics of how cargo has been configured on a 463L pallet for loading on an aircraft.
- PALLET_TYPE: Contains the type of cargo the Pallet ID is related to. Although it is labeled pallet type, this code shows if that cargo is on a single pallet, pallet train, skid, or rolling stock.
- MNFS_ID: Manifest ID number.

GATES Space Utilization

To determine the utilization rate of cargo capacity, as it pertains to aircraft departing Afghanistan and Iraq, GATES data from May 2010 to May 2011 was downloaded and combined into one spreadsheet, including the passenger data and cargo data that were extracted separately. Since the fields did not match up perfectly from the extraction, the passenger and cargo data were combined by matching QTSeq, APOE_APC, APOD_APC, APOE_ICAO, APOE_LEG_ID, and APOD_ICAO with their exact equivalents. The mission identification number (MISSION_ID) was matched with passenger APOE_MSN_ID column. The planned departure time (PLND_DEP_TM) was matched with the departure date/time (DEP_DT_TM). The aircraft type (ACTYPE) was matched with the model design series (MDS). For ease of data manipulation, the total passenger number (TOTAL_PAX) is aligned with the pallet identification number (PAL_ID), and the total passenger weight (TOTAL_PAX_WT) is aligned with PAL_DT.

The data was then filtered for cargo only and for cargo and passenger data. The data provided was in multiple spreadsheets and had to be combined into one worksheet for further filtering. After the data was combined, it was sorted by aircraft type, and all rows, except those associated with C-17 (C017A) and C-5 (C005A, C005B, and C005M) flights, were eliminated. The data was then sorted by Aerial Port of Embarkation (APOE), and all rows, except those pertaining to flights with an APOE of Iraq (OR**) and Afghanistan (OA**), were deleted. The data was then sorted by Aerial Port of Debarkation (APOD), and all rows where the APOD was an ICAO within the Area of Responsibility, such as Afghanistan, Iraq, Qatar, Oman, Kuwait, Saudi Arabia, etc. or the

field was blank, were deleted. This eliminated pallets not destined for destinations outside of the AOR.

Next, the total passenger weight column (TOTAL_PAX_WT) is assumed to be the best available passenger weight. However, to ensure the data is as accurate as possible, the gross weight of the passengers is calculated by multiplying TOTAL_PAX by 250 pounds, if the TOTAL_PAX_WT column was 0 with a TOTAL_PAX number greater than 0. 250 pounds is a generally accepted passenger movement value of the average weight per passenger with their bags.

It was then determined there were duplicate rows of data. Deleting these duplicates line by line proved to be a very arduous process, so Microsoft Excel logic was used to negate their effects on the data. First, the data was sorted by the ATMS_ID. Next, a column dubbed "DUP_OFFSET" was inserted as COLUMN F. To negate the duplication of passenger data, the formula =IF(B2=B1,0,E2) looks for duplicate MSN_IDs and only returns one passenger weight value for the duplicate lines. For the cargo data, the formula is the same but looks for duplicate PAL_IDs and only returns one pallet weight value for the duplicate lines. To retain the proper values for any future resorts, the values of the cells were then copied and then pasted (values only) into a new COLUMN G (GRS WT) and COLUMN F was deleted.

After that, no one field gives the total cargo and passenger weight for each aircraft, as the cargo data is provided by individual pallet identification number and not for the aircraft as a whole. To determine the total weight on the aircraft during each

mission, the data was sorted by the APOE_MSN_ID field. A new column was inserted to compare the APOE_MSN_ID of each row and sum up the weights. The formula, inserted as COLUMN L, was =IF(H2=H1,F2+L1,F2). This compared the APOE_MSN_ID for the leg to the one above it. If they have the same ID, it added its weight to the running weight in the column. If they have a different ID, it started a new running total by placing its own weight in the running weight column.

Additionally, to make it easier to determine the total weight loaded on the aircraft, a new column, COLUMN M, was inserted with the formula =IF(H2=H3,0,L2). This compares the weight in the COLUMN L to determine the maximum and thus total gross weight loaded on the airplane. The data for Iraq and Afghanistan was then separated into different spreadsheets based on APOE. Finally, to determine the average utilization of the aircraft based on aircraft type, the data in COLUMN N was totaled using the formula =SUMIF($P$2:$P$4475,"C005*",$M$2:$M$4475) and divided by the total number of applicable missions. This was determined by counting the number of applicable sorties using =COUNTIFS($M$2:$M$4475,">0",$P$2:$P$4475,"C005*"). The data for Afghanistan and Iraq was then summarized into a table based on aircraft type.

Airlift versus Sealift

It was explored in the literature when sealift is more beneficial than airlift. However, to determine which is more efficient for the DOD to use, the cost differences must be explored. This will be done by evaluating airlift costs versus sealift costs for equipment traveling from Iraq and Afghanistan to Dover AFB. In 2008, AMC/A3

commissioned a study by Cyintech Corporation to evaluate the "Cost-to-Carry" penalties associated with weight added to each of its cargo carrying airplanes (Turcotte, 2011). Cyintech did a regression analysis based on data derived from the Aircraft Communications Addressing and Reporting System (ACARS) history of the airplanes. The AMC Fuel Efficiency office uses these penalties to calculate potential fuel penalties involved in carrying extra weight not needed for the sortie, such as extra equipment or additional cargo. Table 4 summarizes the cost-to-carry penalties for each airframe.

Table 4: Summary of Cost-to-Carry Penalties

MDS	Penalty
C-5	5.67%
C-17	4.40%
C-130	3.00%
KC-10	4.47%
KC-135	4.97%

The penalties are then applied using Equation 1, which returns the additional fuel requirement in pounds.

Equation 1: Fuel Required to Carry Additional Weight

$$W * PCC * T$$

Where:
W = weight in hundreds of pounds
P_{CC} = cost-to-carry penalty
T = flight time in hours

Knowing the additional fuel requirements, the cost per hundred pounds of cargo can be determined by applying JP-8 weighs 6.71 pounds per gallon, and the current DOD Standard Price for JP-8 is $3.95 per gallon. However, first, the average flying time in hours is between Iraq and Dover and Afghanistan and Dover for the C-5 and C-17 must

be determined. The same GDSS data used to determine average cargo capacity also provides actual flying times (ACT_FLYING_TIME) for sorties in minutes. Knowing C-17s normally travel from the AOR to Dover with an intermediate stop in Germany and C-5s normally travel from the AOR to Dover with an intermediate stop in Spain (an example is depicted in Figure 1), average flying times by MDS is easily computed using an Excel AVERAGEIF formula that filters by MDS, departure ICAO, and arrival ICAO. These averages are summarized in Table 5.

Figure 1: Air and Sea Routing from Afghanistan

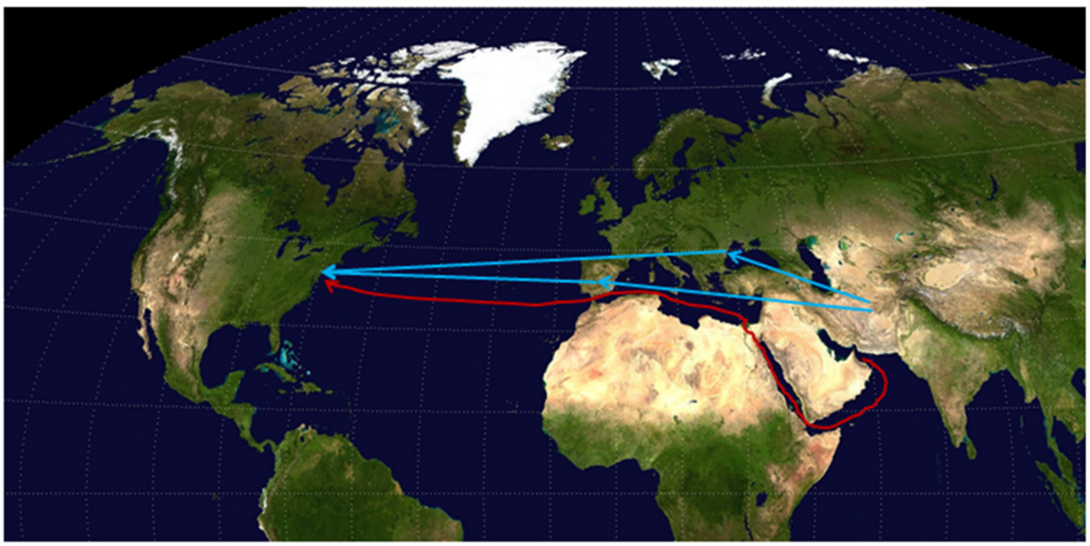


Table 5: Summary of Average Flight Times

MDS	Route	Avg Flight Time (hours)	Route	Avg Flight Time (hours)	Avg Total Flt Time (hours)
C-17	Afghanistan to Germany	8.41	Germany to Dover	9.64	18.05
	Iraq to Germany	5.28			14.92
C-5	Afghanistan to Spain	10.26	Spain to Dover	8.24	18.50
	Iraq to Spain	6.87			15.11

The average flight times and cost-to-carry penalties by airframe can now be entered into Equation 1 to determine the fuel costs involved in loading additional cargo onto the flights. Dividing this result by 6.71 pounds per gallon for JP-8 and multiplying

by JP-8's cost of $3.95 per gallon results in the averages costs summarized in Table 6. Multiplying the cost per 100 pounds by the planning cargo load of the each airframe (C-17 is 900 in 100 pounds and C-5 is 1,500 in 100 pounds) provides the cost of flying a fully laden aircraft versus an empty aircraft. The price per pound would then be the cost in the table divided by 100.

Table 6: Summary of Average Cost of Additional Weight Carried

MDS	Route	Cost per 100 pounds	Fully Laden Cost
C-17	Afghanistan to Germany to Dover	$ 46.75	$ 42,077.21
	Iraq to Germany to Dover	$ 38.65	$ 34,780.72
C-5	Afghanistan to Spain to Dover	$ 61.75	$ 92,623.38
	Iraq to Spain to Dover	$ 50.43	$ 75,650.77

These cost-to-carry penalties for putting opportune cargo on the airframe can then be compared to the costs associated with shipping the same amount for airlift to determine which one is more cost efficient. From Appendix C, the shipping costs of a standard cargo container from the Arabian Gulf to the East Coast is $153.72 per metric ton and from Afghanistan to the East Coast is $404.59. As was previously discussed, a standard twenty-foot equivalent unit (TEU) has an average capacity of approximately 29.3 MTONs. Therefore, the movement of one shipping container capable of holding 47,900 pounds would cost $4504 from the Arabian Gulf ($153.72/MTON **X** 29.3 MTONs/container) and $11,854.49 from Afghanistan ($404.59/MTON **X** 29.3 MTONs/container). Based on these container shipment costs, it can then be determined how much cargo can be airlifted before it is cheaper to move it by sea. To do this, divide the container shipping cost by the price to ship per pound. These calculations were then summarized in a table.

Summary

This chapter began by analyzing how cargo capacity was being utilized on C-5s and C-17s worldwide, based on GDSS data. It then narrowed the focus to the use of cargo capacity on C-5 and C-17 retrograde missions from Afghanistan and Iraq using GDSS and GATES data. Knowing the additional cargo capacity available, the cost to carry additional cargo by airlift was compared to equivalent sealift costs to determine if it would be more advantageous to the DOD to utilize the additional airlift capacity in lieu of sealift.

IV. Analysis and Results

Chapter Overview

This chapter begins with the review of the results of overall C-17 and C-5 worldwide capacity utilization. It is then further refined to look at only missions departing Afghanistan and Iraq. After determining the amount of unutilized AOR capacity, decision points will be determined for utilizing the capacity versus allowing it to be moved via sealift. Finally, the objectives posed at the beginning of this project will be reviewed to determine if they were all answered.

Results of Scenarios

Table 7 shows the aircraft capacity utilized for all C-5 and C-17 aircraft worldwide that do not return to their original departure location, based on data extracted for flights between November 2009 and October 2011 from GDSS. As shown, the C-17

is on average only hauling 3.41% of its available capacity, and the C-5 is only hauling 4.27%. This represents a significant underutilization of capacity.

Table 7: Summary of GDSS Capacity Used Worldwide

Aircraft	Capacity (lbs)	Avg Used (lbs)	% Capacity Used
C-17	90,000	3,066.3	3.41%
C-5	150,000	6,408.5	4.27%

Table 8 shows the aircraft capacity utilized for aircraft departing out of Iraq and Afghanistan, based on the data extracted from GDSS. As shown, total capacity utilization for cargo coming out of theater continues to be an issue for AMC assets. Only utilizing 15.7% to 30.31% of total cargo weight capacity represents a significant inefficiency, especially considering USTRANSCOM's efforts to create "distribution initiative(s) with the underlying goal(s) of improving velocity, precision, visibility, and efficiency" (McNabb, 17 Dec 08). It was decided to try and compare it to data extracted from GATES.

Table 8: Summary of GDSS Capacity Used in Iraq and Afghanistan

Aircraft Type	Departure Country	Capacity (lbs)	Average Used (lbs)	% Capacity Used
C-5	Afghanistan	150,000	30,511.7	20.34%
C-17	Afghanistan	90,000	14,106.1	15.67%
C-5	Iraq	150,000	45,468.0	30.31%
C-17	Iraq	90,000	17,058.4	18.95%

In the end, there were 86 C-5 and 1160 C-17 combined cargo and passenger Afghanistan missions and 82 C-5 and 297 Iraq missions from GATES. Table 9 summarizes the aircraft capacity utilized for aircraft departing out of Iraq and Afghanistan. While the values do not match those from GDSS, the GATES data also shows low total capacity utilization for cargo coming out of theater with a high of 30.24% and a low of 11.11%.

Table 9: Summary of GATES Capacity Used

Aircraft Type	Departure Country	Capacity (lbs)	Average Used (lbs)	% Capacity Used
C-5	Afghanistan	150,000	16,672.5	11.11%
C-17	Afghanistan	90,000	15,168.9	16.85%
C-5	Iraq	150,000	45,354.2	30.24%
C-17	Iraq	90,000	19,171.2	21.30%

Since there is underutilized capacity for most C-5 and C-17 missions, USTRANSCOM needs to understand the affect of weight penalties for utilizing this capacity to haul more cargo. Table 10 shows the decision weights for standard routing of C-17 and C-5 missions returning to the East Coast from Afghanistan and Iraq. As shown, if time is not a factor, cargo weights above 25,255.86 pounds for the C-17 and 19,197.89 pound for the C-5 coming out of Afghanistan should be shipped. For missions out of Iraq, the decision weights are 11,654.73 pounds for the C-17 and 8,930.51 pounds for the C-5.

Table 10: Summary of Cargo Decision Weights

MDS	Route	Decision Weight (lbs)
C-17	Afghanistan to Germany to Dover	25,355.86
	Iraq to Germany to Dover	11,654.73
C-5	Afghanistan to Spain to Dover	19,197.89
	Iraq to Spain to Dover	8,930.51

Investigative Questions Answered

The questions posed at the beginning of this project with their answers are:

What is the amount of available airlift flowing back to CONUS from Afghanistan and Iraq?

This project shows there is a significant amount of unutilized capacity available on airlift flowing back to CONUS. From Afghanistan, there are approximately 76,000 pounds on the C-17 and 119,500 pounds on the C-5 of unutilized capacity. From Iraq, there are 73,000 pounds on the C-17 and 94,500 pounds on the C-5.

What is the cost of flying C-17s and C-5s back to CONUS empty vs. flying them back with full cargo loads?

Based on the cost-to-carry penalties computed previously, the additional cost of flying back a C-17 with a full cargo load from Afghanistan is $42,077.21 and $34,780.72 from Iraq. For the C-5, the costs are $92,623.28 from Afghanistan and $75,650.77 from Iraq.

What is the increased cost of fully laden C-17s and C-5s to the cost of using sealift to ship cargo to CONUS?

By weight, two shipping TEUs are able to hold the planning cargo capacity of the C-17 (90,000 pounds). From Afghanistan, the cost of moving these two containers would be $23,708.98 versus $42,077.21 by air. For Iraq, these values would be $9,008.00 versus $34,780.72. By weight, approximately three shipping TEUs are able to hold the

planning cargo capacity of the C-5 (150,000 pounds). From Afghanistan, the cost of moving these three containers would be $35,563.47 versus $92,623.28 by air. For Iraq, these values would be $13,512.00 versus $75,650.77.

What is a method for determining the cost and benefit of utilizing excess cargo capacity flowing back to the CONUS?

The method is to compare determine weights were it is more efficient to fly the cargo back to the CONUS versus shipping it. Based on the standard routing for the C-17 from Afghanistan and Iraq through Germany to Dover AFB, these weights were determined to be 25,356 and 11,655 pounds. For the standard routing of the C-5 from Afghanistan and Iraq through Spain to Dover AFB, these weights were determined to be 19,198 and 8,931 pounds.

Summary

This chapter reviewed the results of overall C-17 and C-5 worldwide capacity utilization. To narrow the focus to retrograde operations out of Afghanistan and Iraq, this data was refined to look at only missions departing these locations. After determining the amount of unutilized AOR capacity, decision points were determined for utilizing the capacity versus allowing it to be moved via sealift. Finally, the objectives posed at the beginning of this project were reviewed and answered.

V. Conclusions and Recommendations

Chapter Overview

The objectives of this research was to determine the amount of C-17 and C-5 airlift flowing back from Afghanistan and Iraq, the cost of flying these aircraft empty versus fully loaded, the costs differences between loaded aircraft compared to sealift rates, and a method to determine the most cost efficient way for utilizing airlift capacity versus sealift. This was done by analyzing GDSS and GATES data for available capacity, calculating airlift costs utilizing cost-to-carry penalties, determining sealift rates, and combining this data to determine the optimal use of airlift and sealift for retrograde operations. This chapter presents the major conclusions, research significance, and recommendations for action and future study based on the results and analysis of this research.

Conclusions of Research

As the Distribution Process Owner, USTRANSCOM continues to focus on the effective and efficient ways to move cargo throughout the world. In 2007, it opened its Fusion Center to be "the DPO's and the combatant commands' operation arm with a mission to serve as the single coordination and synchronization element to manage current operations within the Joint Deployment and Distribution Enterprise and to achieve the commander's intent" (Johnson, 2011). The Fusion Center continues to research and develop cost-saving initiatives that still meet the needs of its customers. This research is another tool in the tool kit for transportation planners.

Despite past emphasis by GAO reporting on the underutilization of aircraft capacity, this research found there is still a significant amount available airlift on C-17 and C-5 airplanes traveling throughout the globe today. Specifically, C-17's and C-5's are only seeing a worldwide capacity utilization rate of 3.4% and 4.3% respectively. With regards to aircraft departing the Afghanistan and Iraq AORs, they are only being filled to 11% to 30% of their capacity. While this would seem to be an easy area to target to improve the usage rates of the aircraft, this research shows loading additional weight on these aircraft is often not the right answer with regards to cost efficiency.

When time is not a factor for the movement of the cargo, it is very difficult to overcome the cost differentials between air and sea transportation. The cost of flying a C-17 at its maximum peacetime planning ACL from Afghanistan through Germany to Dover AFB is $42,077.21 versus $23,708.98 by sea. From Iraq, it is $34,780.72 versus $9,008.00 by sea. For a C-5 flying from Afghanistan through Spain to Dover AFB, it is $92,623.28 versus $35,563.47 by sea. From Iraq, it is $75,650.77 versus $13,512.00 by sea. These cost differentials cannot be easily ignored and should promote a renewed focus on commercial sea transportation within USTRANSCOM.

While this particular portion of the analysis focused on maximizing cargo capacity, there are decision points when adding cargo to the aircraft already returning to CONUS is cheaper than shipping it. For the C-17, this research was able to determine these decisions points to be 25,356 pounds for Afghanistan missions and 11,655 pounds for Iraq missions. For the C-5, they are 19,198 pounds and 8,931 pounds, respectively.

Table 11 shows a comparison of these decision points to the current utilization of the assets.

Table 11: Summary of Decision Points

MDS	Route	GATES Avg Used (lbs)	GDSS Avg Used (lbs)	Decision Weight (lbs)	GATES Difference	GDSS Difference
C-17	Afghanistan to Germany to Dover	15,168.9	14,106.1	25,355.9	(10,186.96)	(11,249.76)
	Iraq to Germany to Dover	19,171.2	17,058.4	11,654.7	7,516.47	5,403.67
C-5	Afghanistan to Spain to Dover	16,672.5	30,511.7	19,197.9	(2,525.39)	11,313.81
	Iraq to Spain to Dover	45,354.2	45,468.0	8,930.5	36,423.69	36,537.49

The negative values in this table show potential additional airlift capacity, and the positive values show where capacity could be shifted to sealift. In general, most flights are being loaded past their calculated decision points. In particular, C-5's operating out of Iraq are carrying over 36,000 pounds of cargo that could be shipped at far less cost. However, for both the GDSS and GATES data, C-17's operating out of Afghanistan should be the biggest target for the use of additional airlift capacity. The data conflicts for C-5 aircraft operating out of the same theater. GATES shows the availability of some airlift capacity, while GDSS shows airplanes carrying too much. This is likely due to the differing timeframes of the data used from each system.

Overall, this research provides answers to the four objectives it targeted. The most beneficial of these are the distinct decision points for more cost efficient Afghanistan and Iraq retrograde operations. It also provides the architecture to analyze future air and sea operations to improve cost efficiency.

Recommendations for Action

While this project focused on retrograde operations from the Afghanistan and Iraq AORs, all operations where timelines allow for flexible transportation options could benefit from this analysis. The author recommends, whenever planners decide to use airlift, the cost-to-carry penalties should be used evaluate costs. Then, DOD planners should utilize the analysis and results of this project to formally establish decision points for when to utilize interthearter airlift over sealift. Understanding the cost differences will help the DOD better utilize its funds and transportation assets.

The author also recommends a review of port hold time policies. In particular, the emphasis on 72-hour port hold metrics should be evaluated. Changes in these policies could allow planners the flexibility to utilize more cost effective modes of transportation.

Recommendations for Future Research

Considering this project as a first step, there are numerous opportunities for further research into or expansion of this topic. This project did not include an analysis of port handling costs. Additionally, it did not move the cargo by truck or rail after its airlift to Dover AFB. Further research into the addition of these costs may alter the decision points.

Further, this project focused on retrograde operations from Afghanistan and Iraq, but it could be applied to all flight operations. The author recommends further research into its applicability to all flight and sea operations. This could be done through the

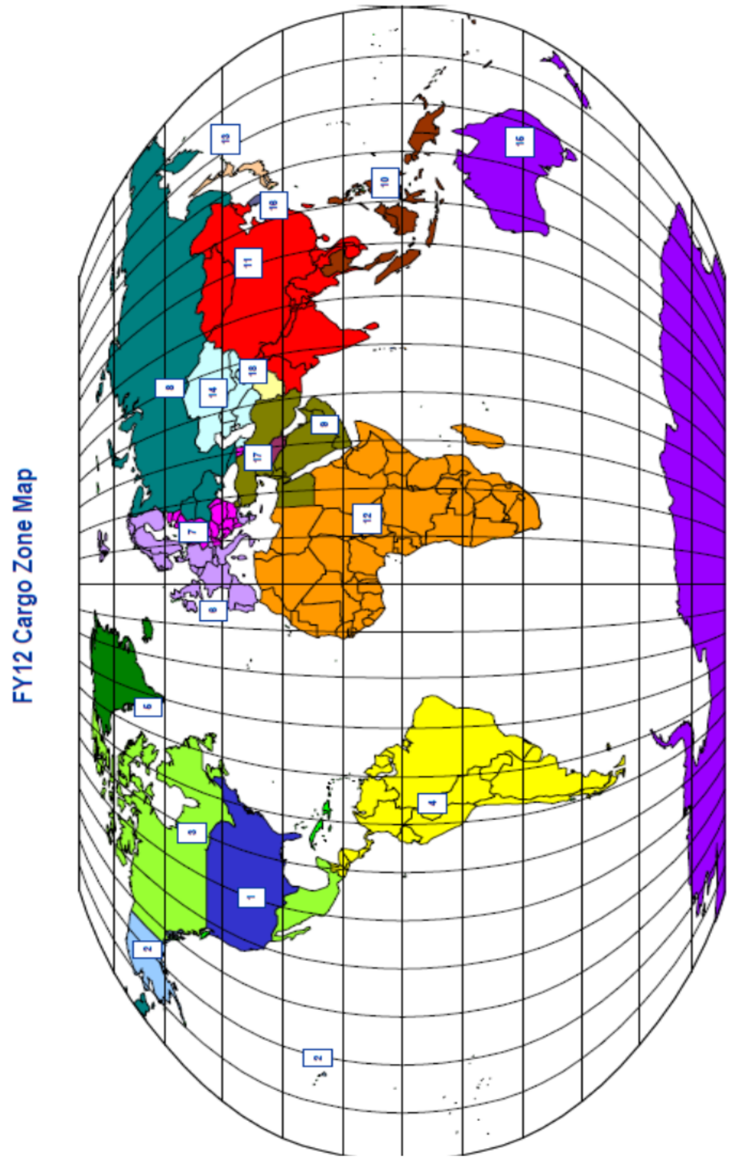
development of a user-friendly model. USTRANSCOM Fusion Center or aerial port planners would then have an easy-to-use medium to optimize airlift and sealift assets.

Summary

This chapter provides the major conclusions drawn from this research. It also provides recommendations for action and further research. Overall, the results of this research indicate an inefficient use of C-17 and C-5 airlift assets for cargo operations out of Afghanistan and Iraq. It recommends planners focus more closely on the cost advantages of sealift and use the calculated decision points as a baseline for more efficient operations in the future.

Appendix A

Channel Cargo Zones (USTRANSCOM, 2011)



Appendix B

Channel Cargo Zone Rates (USTRANSCOM, 2011)

FY12 Department of Defense Channel Cargo Tariffs

			Dept of Defence Channel Cargo Tariffs (Dollars Per Pound)				
POE	POD	Zone to Zone	0 to 439 LBS	440 to 1099 LBS	1100 to 2199 LBS	2200 to 3599 LBS	3600+ LBS
1	2	1-2	3.322	2.987	2.660	2.322	2.044
1	3	1-3	2.454	2.206	1.965	1.715	1.510
1	4	1-4	3.692	3.320	2.957	2.580	2.272
1	5	1-5	5.561	5.001	4.454	3.887	3.422
1	6	1-6	3.018	2.714	2.417	2.109	1.350
1	7	1-7	4.232	3.806	3.389	2.958	2.604
1	8	1-8	5.292	4.759	4.238	3.699	3.257
1	9	1-9	3.784	3.403	3.030	2.645	2.328
1	10	1-10	3.130	2.815	2.507	2.188	1.926
1	11	1-11	4.038	3.631	3.234	2.822	2.485
1	12	1-12	5.514	4.958	4.416	3.854	3.393
1	13	1-13	3.208	2.885	2.569	2.243	1.974
1	14	1-14	6.058	5.448	4.852	4.234	3.728
1	15	1-15	3.831	3.445	3.068	2.678	2.358
1	16	1-16	4.424	3.978	3.543	3.092	2.722
1	17	1-17	5.723	5.147	4.583	4.000	3.522
1	18	1-18	7.729	6.951	6.190	5.403	4.757
2	1	2-1	3.322	2.987	2.660	2.322	2.044
2	2	2-2	1.390	1.250	1.113	0.972	0.855
2	3	2-3	1.928	1.734	1.544	1.348	1.186
2	4	2-4	3.692	3.320	2.957	2.580	2.272
2	5	2-5	4.962	4.462	3.974	3.468	3.054
2	6	2-6	2.320	2.087	1.858	1.622	1.428
2	7	2-7	3.670	3.301	2.940	2.566	2.259
2	8	2-8	4.857	4.368	3.890	3.395	2.989
2	9	2-9	4.038	3.631	3.234	2.822	2.485
2	10	2-10	4.610	4.145	3.692	3.222	2.837
2	11	2-11	3.324	2.989	2.662	2.323	2.046
2	12	2-12	4.824	4.338	3.863	3.372	2.968
2	13	2-13	1.818	1.635	1.456	1.271	1.119
2	14	2-14	5.292	4.759	4.238	3.699	3.257
2	15	2-15	3.830	3.444	3.067	2.677	2.357
2	16	2-16	2.223	1.999	1.780	1.554	1.368
2	17	2-17	6.122	5.505	4.903	4.279	3.767
2	18	2-18	8.669	7.795	6.942	6.059	5.335
3	1	3-1	2.454	2.206	1.965	1.715	1.510
3	2	3-2	1.928	1.734	1.544	1.348	1.186
3	3	3-3	2.701	2.429	2.164	1.888	1.662
3	4	3-4	1.660	1.493	1.330	1.160	1.022
3	5	3-5	3.400	3.058	2.723	2.377	2.092
3	6	3-6	1.544	1.389	1.237	1.079	0.950
3	7	3-7	2.883	2.593	2.309	2.015	1.774
3	8	3-8	2.883	2.593	2.309	2.015	1.774
3	9	3-9	2.734	2.458	2.189	1.911	1.682
3	10	3-10	1.987	1.786	1.591	1.389	1.222
3	11	3-11	2.024	1.820	1.621	1.415	1.245
3	12	3-12	3.226	2.901	2.583	2.255	1.985
3	13	3-13	1.984	1.784	1.589	1.387	1.221
3	14	3-14	2.883	2.593	2.309	2.015	1.774
3	15	3-15	2.858	2.570	2.289	1.998	1.759
3	16	3-16	1.993	1.792	1.596	1.393	1.226
3	17	3-17	2.877	2.587	2.304	2.011	1.771
3	18	3-18	2.871	2.582	2.299	2.007	1.767
4	1	4-1	3.692	3.320	2.957	2.580	2.272

			Dept of Defence Channel Cargo Tariffs (Dollars Per Pound)				
POE	POD	Zone to Zone	0 to 439 LBS	440 to 1099 LBS	1100 to 2199 LBS	2200 to 3599 LBS	3600+ LBS
4	2	4-2	3.692	3.320	2.957	2.580	2.272
4	3	4-3	1.660	1.493	1.330	1.160	1.022
4	4	4-4	2.545	2.288	2.038	1.779	1.566
4	5	4-5	2.962	2.663	2.372	2.070	1.823
4	6	4-6	4.504	4.050	3.607	3.148	2.772
4	7	4-7	3.018	2.714	2.417	2.109	1.857
4	8	4-8	3.391	3.050	2.716	2.370	2.087
4	9	4-9	4.504	4.050	3.607	3.148	2.772
4	10	4-10	4.409	3.965	3.531	3.082	2.713
4	11	4-11	3.036	2.731	2.432	2.122	1.869
4	12	4-12	3.391	3.050	2.716	2.370	2.087
4	13	4-13	4.347	3.909	3.481	3.038	2.675
4	14	4-14	3.360	3.022	2.691	2.349	2.068
4	15	4-15	3.323	2.988	2.661	2.323	2.045
4	16	4-16	5.826	5.239	4.666	4.072	3.585
4	17	4-17	5.181	4.659	4.149	3.621	3.188
4	18	4-18	3.698	3.325	2.962	2.585	2.276
5	1	5-1	5.561	5.001	4.454	3.887	3.422
5	2	5-2	4.962	4.462	3.974	3.468	3.054
5	3	5-3	3.400	3.058	2.723	2.377	2.092
5	4	5-4	2.962	2.663	2.372	2.070	1.823
5	5	5-5	3.806	3.423	3.048	2.660	2.342
5	6	5-6	3.656	3.287	2.928	2.555	2.250
5	7	5-7	4.042	3.634	3.237	2.825	2.487
5	8	5-8	3.806	3.423	3.048	2.660	2.342
5	9	5-9	5.333	4.796	4.271	3.728	3.282
5	10	5-10	3.901	3.508	3.124	2.727	2.401
5	11	5-11	3.998	3.595	3.202	2.794	2.460
5	12	5-12	3.712	3.338	2.972	2.594	2.284
5	13	5-13	4.646	4.178	3.721	3.247	2.859
5	14	5-14	4.309	3.875	3.451	3.012	2.652
5	15	5-15	4.446	3.999	3.561	3.108	2.736
5	16	5-16	4.938	4.441	3.955	3.452	3.039
5	17	5-17	5.876	5.284	4.706	4.107	3.616
5	18	5-18	4.309	3.875	3.451	3.012	2.652
6	1	6-1	3.018	2.714	2.417	2.109	1.857
6	2	6-2	2.320	2.087	1.858	1.622	1.428
6	3	6-3	1.544	1.389	1.237	1.079	0.950
6	4	6-4	4.504	4.050	3.607	3.148	2.772
6	5	6-5	3.656	3.287	2.928	2.555	2.250
6	6	6-6	1.679	1.510	1.345	1.173	1.033
6	7	6-7	1.866	1.678	1.494	1.304	1.148
6	8	6-8	3.132	2.817	2.509	2.189	1.928
6	9	6-9	2.040	1.835	1.634	1.426	1.255
6	10	6-10	3.222	2.898	2.580	2.252	1.983
6	11	6-11	3.360	3.022	2.691	2.349	2.068
6	12	6-12	5.057	4.547	4.050	3.534	3.112
6	13	6-13	5.503	4.948	4.407	3.846	3.386
6	14	6-14	3.807	3.424	3.049	2.661	2.343
6	15	6-15	2.513	2.260	2.013	1.757	1.547
6	16	6-16	4.601	4.137	3.685	3.216	2.831
6	17	6-17	3.091	2.780	2.476	2.161	1.902
6	18	6-18	4.582	4.121	3.670	3.203	2.820
7	1	7-1	4.232	3.806	3.389	2.958	2.604

			Dept of Defense Channel Cargo Tariffs (Dollars Per Pound)				
POE	POD	Zone to Zone	0 to 439 LBS	440 to 1099 LBS	1100 to 2199 LBS	2200 to 3599 LBS	3600+ LBS
7	2	7-2	3.670	3.301	2.940	2.566	2.259
7	3	7-3	2.883	2.593	2.309	2.015	1.774
7	4	7-4	3.018	2.714	2.417	2.109	1.857
7	5	7-5	4.042	3.634	3.237	2.825	2.487
7	6	7-6	1.866	1.678	1.494	1.304	1.148
7	7	7-7	2.429	2.184	1.945	1.698	1.495
7	8	7-8	4.010	3.606	3.212	2.803	2.468
7	9	7-9	2.429	2.184	1.945	1.698	1.495
7	10	7-10	4.090	3.678	3.276	2.859	2.517
7	11	7-11	2.983	2.682	2.389	2.085	1.836
7	12	7-12	4.931	4.434	3.949	3.446	3.034
7	13	7-13	4.678	4.207	3.747	3.270	2.879
7	14	7-14	2.987	2.686	2.392	2.088	1.838
7	15	7-15	5.359	4.819	4.292	3.746	3.298
7	16	7-16	4.836	4.349	3.873	3.380	2.976
7	17	7-17	5.368	4.827	4.299	3.752	3.303
7	18	7-18	5.333	4.796	4.271	3.728	3.282
8	1	8-1	5.292	4.759	4.238	3.699	3.257
8	2	8-2	4.857	4.368	3.890	3.395	2.989
8	3	8-3	2.883	2.593	2.309	2.015	1.774
8	4	8-4	3.391	3.050	2.716	2.370	2.087
8	5	8-5	3.806	3.423	3.048	2.660	2.342
8	6	8-6	3.132	2.817	2.509	2.189	1.928
8	7	8-7	4.010	3.606	3.212	2.803	2.468
8	8	8-8	3.157	2.839	2.529	2.207	1.943
8	9	8-9	2.987	2.686	2.392	2.088	1.838
8	10	8-10	4.446	3.999	3.561	3.108	2.736
8	11	8-11	4.702	4.228	3.765	3.286	2.893
8	12	8-12	3.712	3.338	2.972	2.594	2.284
8	13	8-13	4.446	3.999	3.561	3.108	2.736
8	14	8-14	3.188	2.867	2.554	2.229	1.962
8	15	8-15	3.678	3.307	2.946	2.571	2.263
8	16	8-16	4.446	3.999	3.561	3.108	2.736
8	17	8-17	5.393	4.850	4.319	3.769	3.319
8	18	8-18	3.438	3.091	2.753	2.403	2.115
9	1	9-1	3.784	3.403	3.030	2.645	2.328
9	2	9-2	4.038	3.631	3.234	2.822	2.485
9	3	9-3	2.734	2.458	2.189	1.911	1.682
9	4	9-4	4.504	4.050	3.607	3.148	2.772
9	5	9-5	5.333	4.796	4.271	3.728	3.282
9	6	9-6	2.040	1.835	1.634	1.426	1.255
9	7	9-7	2.429	2.184	1.945	1.698	1.495
9	8	9-8	2.987	2.686	2.392	2.088	1.838
9	9	9-9	2.429	2.184	1.945	1.698	1.495
9	10	9-10	4.303	3.870	3.446	3.008	2.648
9	11	9-11	2.987	2.686	2.392	2.088	1.838
9	12	9-12	4.008	3.604	3.210	2.801	2.466
9	13	9-13	5.019	4.514	4.020	3.508	3.089
9	14	9-14	4.631	4.164	3.709	3.237	2.850
9	15	9-15	6.352	5.712	5.087	4.440	3.909
9	16	9-16	5.764	5.183	4.616	4.029	3.547
9	17	9-17	4.870	4.379	3.900	3.404	2.997
9	18	9-18	4.988	4.486	3.995	3.487	3.070
10	1	10-1	3.130	2.815	2.507	2.188	1.926

Appendix C

FY12 Container and Breakbulk Shipping Rates (USTRANSCOM, 2011)

FY12 Revised Liner - Breakbulk and Container (Revised TA 01-99, 02-99, 03-99 and 04-99) - Effective 16 Dec 11

Breakbulk (01-09)
Container (11-13)

Traffic Area Code Pair			FY12 SDDC Liner Billing Rates per Measurement Ton										
			Reefer CC-01	Bulk CC-02	POV CC-03	Hazardous CC-04	General CC-06	Trailers CC-07	Special CC-08	Aircraft CC-09	Reefer CC-11	Vehicles CC-12	General CC-13
01 01	CONUS (East Coast)	CONUS (East Coast)	$24.40	$25.47	$29.74	$25.03	$25.47	$36.37	$19.06	$31.73	$61.86	$59.25	$71.20
01 02	CONUS (East Coast)	CONUS (Gulf Coast)	$54.18	$28.17	$32.98	$55.54	$28.17	$40.32	$42.29	$35.25	$99.20	$83.09	$86.33
01 03	CONUS (East Coast)	CONUS (California Coast)	$141.57	$73.76	$86.28	$145.26	$73.76	$105.39	$55.30	$92.13	$178.30	$278.72	$73.07
01 04	CONUS (East Coast)	CONUS (Northwest Coast)	$170.41	$88.75	$103.80	$174.86	$88.75	$126.95	$66.57	$110.96	$138.13	$280.21	$115.18
01 05	CONUS (East Coast)	Canada (Newfoundland)	$45.41	$47.36	$27.65	$46.62	$47.36	$33.82	$35.43	$29.54	$138.67	$140.09	$64.19
01 06	CONUS (East Coast)	Canada (Labrador)	$64.25	$33.47	$39.14	$65.96	$33.47	$47.86	$25.03	$41.81	$138.13	$280.21	$115.18
01 07	CONUS (East Coast)	Canada (Pine Tree)	$82.20	$42.84	$50.09	$84.32	$42.84	$61.22	$32.09	$53.48	$115.92	$105.65	$49.62
01 08	CONUS (East Coast)	Greenland (Thule)	$91.42	$47.59	$55.75	$93.80	$47.59	$68.10	$35.70	$59.50	$115.92	$106.04	$49.62
01 09	CONUS (East Coast)	Iceland	$85.44	$44.47	$104.10	$87.63	$256.36	$63.61	$251.68	$222.41	$122.95	$169.25	$174.65
01 10	CONUS (East Coast)	West Mexico and Central America	$69.24	$36.00	$103.10	$70.96	$236.77	$341.12	$221.04	$44.99	$280.49	$147.34	$81.61
01 11	CONUS (East Coast)	Panama (Caribbean Coast)	$48.50	$25.23	$109.94	$49.75	$286.76	$67.44	$211.35	$31.55	$132.76	$144.92	$142.11
01 12	CONUS (East Coast)	Bermuda Islands	$29.62	$30.78	$36.10	$30.38	$30.78	$44.09	$23.09	$38.50	$198.02	$148.33	$157.99
01 13	CONUS (East Coast)	Lesser Antilles Islands	$200.67	$202.56	$201.46	$207.39	$256.47	$215.99	$313.64	$140.44	$419.33	$253.09	$175.13
01 14	CONUS (East Coast)	Puerto Rico	$62.43	$40.39	$63.57	$39.79	$82.71	$70.95	$77.19	$50.57	$120.77	$205.32	$58.32
01 15	CONUS (East Coast)	Caribbean (Other)	$69.54	$72.52	$294.28	$101.89	$169.73	$160.46	$170.82	$84.71	$122.45	$95.45	$124.39
01 16	CONUS (East Coast)	Cuba (Guantanamo Bay)	$63.78	$133.46	$507.91	$64.70	$446.00	$230.99	$230.73	$82.97	$121.70	$177.63	$111.55
01 17	CONUS (East Coast)	Northern Europe	$118.74	$138.19	$111.78	$128.73	$178.54	$179.17	$151.88	$156.77	$192.70	$95.54	$111.60
01 18	CONUS (East Coast)	British Isles	$108.13	$56.32	$86.68	$110.92	$154.01	$142.08	$164.68	$70.39	$171.59	$103.88	$89.49
01 19	CONUS (East Coast)	Mediterranean (West)	$120.50	$188.55	$384.91	$282.74	$190.46	$272.34	$258.68	$288.38	$174.22	$133.88	$109.15
01 20	CONUS (East Coast)	Mediterranean (East)	$161.24	$117.72	$392.93	$165.46	$182.10	$246.63	$296.79	$209.86	$211.88	$125.48	$133.33
01 21	CONUS (East Coast)	West Africa	$143.82	$74.91	$555.56	$585.60	$579.71	$351.36	$945.08	$93.62	$605.09	$374.91	$309.27
01 22	CONUS (East Coast)	South and East Africa	$245.62	$127.90	$149.61	$251.98	$480.73	$182.89	$306.64	$159.88	$288.78	$278.40	$337.67
01 23	CONUS (East Coast)	Arabian Gulf	$390.89	$362.75	$670.03	$220.42	$351.01	$363.98	$364.17	$210.00	$190.15	$360.00	$153.72
01 24	CONUS (East Coast)	India and Burma	$258.65	$337.33	$294.14	$439.60	$123.26	$340.13	$451.79	$196.74	$301.44	$291.16	$149.24
01 25	CONUS (East Coast)	Alaska (East)	$209.74	$109.21	$127.79	$215.19	$109.21	$156.15	$81.89	$136.55	$138.13	$280.21	$115.18
01 26	CONUS (East Coast)	Alaska (West)	$203.40	$105.94	$123.94	$208.80	$105.94	$151.53	$79.47	$132.47	$138.13	$280.21	$115.18
01 27	CONUS (East Coast)	Hawaiian Islands	$191.56	$99.77	$116.72	$196.54	$99.77	$142.71	$74.87	$124.70	$299.05	$207.12	$118.43
01 28	CONUS (East Coast)	Marshall Islands	$257.16	$133.94	$156.68	$263.88	$133.94	$191.51	$100.48	$167.47	$194.22	$182.09	$127.12
01 29	CONUS (East Coast)	Marianas Islands	$277.58	$144.55	$169.20	$284.83	$144.55	$206.73	$108.41	$180.73	$299.05	$207.12	$118.43
01 30	CONUS (East Coast)	Taiwan	$304.18	$158.45	$185.33	$312.05	$158.45	$226.58	$412.14	$198.02	$323.72	$725.79	$226.29
01 31	CONUS (East Coast)	Bonin Islands	$289.32	$150.69	$176.26	$296.83	$150.69	$215.40	$113.06	$188.36	$138.13	$280.21	$115.18
01 32	CONUS (East Coast)	Philippines	$320.46	$166.92	$195.28	$328.79	$211.29	$302.15	$198.45	$407.25	$150.99	$217.82	$109.03
01 33	CONUS (East Coast)	Thailand	$326.86	$170.22	$199.22	$335.39	$319.25	$243.44	$127.68	$212.84	$150.99	$217.82	$141.52
01 34	CONUS (East Coast)	New Guinea and Australia	$287.66	$149.80	$175.27	$295.14	$149.80	$214.25	$112.31	$187.22	$284.57	$433.22	$216.72
01 35	CONUS (East Coast)	Great Lakes Area	$68.34	$35.59	$41.63	$70.12	$35.59	$50.91	$26.70	$44.47	$138.13	$280.21	$115.18
01 37	CONUS (East Coast)	Alaska (Aleutian Islands)	$222.64	$115.92	$135.65	$228.39	$115.92	$165.82	$86.92	$144.91	$138.13	$280.21	$115.18
01 38	CONUS (East Coast)	North Central Pacific Islands	$218.03	$113.59	$132.87	$223.73	$113.59	$162.37	$85.14	$141.93	$138.13	$280.21	$115.18
01 39	CONUS (East Coast)	South Pacific Islands	$209.38	$109.08	$127.60	$214.82	$109.08	$155.97	$81.76	$136.31	$138.13	$280.21	$115.18
01 40	CONUS (East Coast)	South West Pacific Islands	$308.10	$160.47	$187.77	$316.08	$160.47	$229.46	$120.32	$200.55	$138.13	$280.21	$115.18
01 42	CONUS (East Coast)	Scandinavia	$136.73	$71.25	$85.76	$102.17	$167.18	$213.74	$191.49	$89.00	$190.09	$184.61	$224.55
01 43	CONUS (East Coast)	Black Sea	$178.66	$93.01	$108.90	$183.34	$447.23	$338.45	$402.02	$116.30	$354.61	$182.65	$190.14
01 44	CONUS (East Coast)	South America (West Coast)	$106.45	$55.48	$259.38	$109.25	$111.41	$79.30	$309.05	$69.28	$156.15	$103.28	$114.81
01 45	CONUS (East Coast)	South America (East Coast)	$156.93	$81.71	$189.76	$161.01	$305.11	$116.85	$61.27	$102.14	$207.25	$124.96	$210.36
01 46	CONUS (East Coast)	Azores	$77.73	$57.05	$103.33	$79.82	$263.07	$348.74	$419.80	$50.64	$313.00	$94.45	$180.62

Traffic Area Code Pair			Reefer CC-01	Bulk CC-02	POV CC-03	Hazardous CC-04	General CC-06	Trailers CC-07	Special CC-08	Aircraft CC-09	Reefer CC-11	Vehicles CC-12	General CC-13
			FY12 SDDC Liner Billing Rates per Measurement Ton										
01 47	CONUS (East Coast)	Antarctica	$262.55	$136.73	$159.99	$269.37	$136.73	$195.54	$102.57	$170.90	$138.13	$280.21	$115.18
01 48	CONUS (East Coast)	Vietnam	$320.95	$167.17	$195.59	$329.36	$167.17	$239.06	$125.37	$208.98	$138.13	$280.21	$124.75
01 49	CONUS (East Coast)	South East Asia (Other)	$301.29	$156.93	$183.56	$309.09	$376.33	$427.19	$339.40	$196.10	$460.58	$542.91	$391.76
01 50	CONUS (East Coast)	Ryukyu Islands	$292.22	$152.20	$178.05	$299.86	$152.20	$217.61	$114.16	$190.25	$274.89	$186.65	$223.10
01 51	CONUS (East Coast)	Korea	$281.31	$146.49	$171.43	$252.02	$581.07	$209.50	$361.02	$435.80	$274.89	$328.35	$111.54
01 52	CONUS (East Coast)	Japan	$278.26	$144.91	$169.53	$285.46	$218.32	$205.51	$217.30	$181.14	$288.32	$162.32	$133.98
01 54	CONUS (East Coast)	Rhine River	$113.64	$59.17	$69.24	$116.59	$236.82	$84.69	$117.03	$73.97	$138.13	$280.21	$271.69
01 55	CONUS (East Coast)	Cambodia	$337.71	$175.92	$205.77	$346.52	$264.92	$251.53	$131.92	$219.87	$564.90	$602.53	$179.19
01 56	CONUS (East Coast)	Panama (Pacific Coast)	$52.42	$27.30	$105.05	$53.78	$54.60	$39.03	$76.28	$34.11	$168.33	$189.96	$221.26
01 57	CONUS (East Coast)	Indian Ocean	$340.84	$177.55	$207.73	$349.72	$177.55	$253.92	$225.90	$221.89	$311.56	$299.48	$130.99
01 59	CONUS (East Coast)	Russia	$93.42	$63.14	$124.18	$184.81	$110.21	$77.23	$221.76	$161.72	$138.13	$280.21	$115.18
01 99	CONUS (East Coast)	Afghanistan	$111.09	$382.00	$102.70	$149.86	$322.78	$605.74	$350.03	$396.00	$497.80	$351.08	$394.05
02 02	CONUS (Gulf Coast)	CONUS (Gulf Coast)	$46.19	$24.04	$28.07	$47.36	$24.04	$34.46	$18.01	$30.08	$138.13	$280.21	$154.60
02 03	CONUS (Gulf Coast)	CONUS (California Coast)	$136.39	$71.01	$83.09	$139.93	$71.01	$101.56	$53.24	$88.82	$138.13	$280.21	$115.18
02 04	CONUS (Gulf Coast)	CONUS (Northwest Coast)	$163.83	$85.33	$99.85	$168.11	$85.33	$122.06	$64.02	$106.66	$138.13	$280.21	$115.18
02 05	CONUS (Gulf Coast)	Canada (Newfoundland)	$84.69	$44.04	$51.59	$86.87	$44.04	$63.06	$33.10	$55.12	$138.13	$280.21	$115.18
02 06	CONUS (Gulf Coast)	Canada (Labrador)	$103.64	$53.96	$63.12	$106.29	$53.96	$77.15	$40.49	$67.45	$138.13	$280.21	$115.18
02 07	CONUS (Gulf Coast)	Canada (Pine Tree)	$111.84	$58.26	$68.14	$114.80	$58.26	$83.31	$43.71	$72.84	$138.13	$280.21	$115.18
02 08	CONUS (Gulf Coast)	Greenland (Thule)	$135.91	$70.78	$82.77	$139.47	$70.78	$101.21	$53.07	$88.48	$138.13	$280.21	$115.18
02 09	CONUS (Gulf Coast)	Iceland	$123.70	$64.42	$75.38	$126.89	$64.42	$92.07	$48.33	$80.54	$138.13	$280.21	$115.18
02 10	CONUS (Gulf Coast)	West Mexico and Central America	$52.17	$27.12	$31.81	$53.48	$68.64	$38.85	$140.20	$34.00	$165.15	$462.66	$162.48
02 11	CONUS (Gulf Coast)	Panama (Caribbean Coast)	$50.04	$26.07	$105.95	$51.34	$104.23	$69.53	$210.95	$32.57	$150.39	$100.06	$89.09
02 12	CONUS (Gulf Coast)	Bermuda Islands	$60.92	$31.68	$37.13	$62.54	$31.68	$45.35	$47.61	$39.68	$138.13	$280.21	$115.18
02 13	CONUS (Gulf Coast)	Lesser Antilles Islands	$148.38	$144.64	$134.31	$150.05	$136.18	$68.58	$308.69	$120.00	$261.39	$228.97	$245.08
02 14	CONUS (Gulf Coast)	Puerto Rico	$53.88	$28.07	$58.22	$55.24	$112.26	$40.08	$104.19	$35.06	$141.68	$132.72	$93.00
02 15	CONUS (Gulf Coast)	Caribbean (Other)	$53.29	$27.78	$145.02	$54.72	$185.41	$198.74	$325.57	$34.70	$131.47	$110.31	$163.88
02 16	CONUS (Gulf Coast)	Cuba (Guantanamo Bay)	$55.30	$132.72	$508.76	$60.83	$342.86	$176.96	$176.96	$82.95	$110.60	$165.90	$105.07
02 17	CONUS (Gulf Coast)	Northern Europe	$153.91	$92.97	$93.80	$157.86	$270.55	$262.34	$256.37	$175.50	$296.00	$109.84	$209.23
02 18	CONUS (Gulf Coast)	British Isles	$143.55	$74.73	$87.46	$147.21	$247.59	$195.36	$251.13	$93.46	$155.81	$177.73	$149.04
02 19	CONUS (Gulf Coast)	Mediterranean (West)	$167.39	$87.17	$101.96	$171.72	$291.55	$258.21	$285.21	$203.52	$347.77	$138.87	$149.35
02 20	CONUS (Gulf Coast)	Mediterranean (East)	$194.53	$101.32	$118.49	$199.53	$206.11	$406.20	$285.23	$126.60	$247.14	$216.13	$201.12
02 21	CONUS (Gulf Coast)	West Africa	$153.80	$80.11	$679.22	$523.72	$745.04	$269.14	$497.68	$100.12	$514.19	$161.50	$193.60
02 22	CONUS (Gulf Coast)	South and East Africa	$283.57	$147.62	$172.79	$290.92	$686.00	$211.16	$541.94	$184.58	$237.56	$398.80	$303.40
02 23	CONUS (Gulf Coast)	Arabian Gulf	$412.76	$134.63	$167.13	$463.44	$285.73	$389.47	$386.18	$157.70	$177.89	$285.48	$301.63
02 24	CONUS (Gulf Coast)	India and Burma	$270.96	$141.09	$165.10	$277.95	$485.02	$428.34	$477.20	$176.41	$280.75	$349.80	$364.98
02 25	CONUS (Gulf Coast)	Alaska (East)	$194.00	$101.04	$118.21	$199.09	$101.04	$144.50	$75.78	$126.32	$138.13	$280.21	$115.18
02 26	CONUS (Gulf Coast)	Alaska (West)	$201.34	$104.87	$122.64	$206.56	$104.87	$149.94	$78.64	$131.03	$138.13	$280.21	$115.18
02 27	CONUS (Gulf Coast)	Hawaiian Islands	$181.32	$94.40	$110.48	$186.01	$94.40	$135.06	$70.84	$118.02	$138.13	$185.58	$115.18
02 28	CONUS (Gulf Coast)	Marshall Islands	$239.87	$124.96	$146.14	$246.16	$124.96	$178.66	$93.67	$156.15	$138.13	$280.21	$115.18
02 29	CONUS (Gulf Coast)	Marianas Islands	$274.45	$142.94	$167.24	$281.58	$142.94	$204.40	$107.18	$178.66	$230.65	$205.07	$92.74
02 30	CONUS (Gulf Coast)	Taiwan	$300.04	$156.29	$182.87	$307.84	$156.29	$223.48	$117.19	$195.35	$138.13	$280.21	$115.18
02 31	CONUS (Gulf Coast)	Bonin Islands	$269.80	$140.52	$164.43	$276.83	$140.52	$200.98	$105.39	$175.62	$138.13	$280.21	$115.18
02 32	CONUS (Gulf Coast)	Philippines	$309.68	$161.32	$188.72	$317.73	$161.32	$230.65	$120.93	$201.58	$132.70	$138.32	$83.79
02 33	CONUS (Gulf Coast)	Thailand	$361.55	$188.32	$220.35	$370.99	$347.38	$269.30	$141.23	$235.38	$138.13	$280.21	$115.18
02 34	CONUS (Gulf Coast)	New Guinea and Australia	$297.09	$154.72	$181.02	$304.85	$195.85	$221.21	$116.01	$193.40	$284.57	$292.64	$148.24
02 38	CONUS (Gulf Coast)	North Central Pacific Islands	$220.64	$114.87	$134.41	$226.32	$114.87	$164.32	$86.16	$143.59	$138.13	$280.21	$115.18
02 39	CONUS (Gulf Coast)	South Pacific Islands	$208.50	$108.55	$127.01	$213.87	$108.55	$155.26	$81.40	$135.71	$138.13	$280.21	$115.18
02 40	CONUS (Gulf Coast)	South West Pacific Islands	$293.21	$152.73	$178.71	$300.85	$152.73	$218.44	$114.54	$190.91	$138.13	$280.21	$115.18
02 42	CONUS (Gulf Coast)	Scandinavia	$93.42	$63.14	$124.18	$184.81	$110.21	$77.23	$134.56	$161.72	$140.09	$85.16	$158.30

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Optimizing Aircraft Utilization for Retrograde Operations

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Introduction

USTRANSCOM focuses on the effective and efficient ways to move cargo world wide. Its Fusion Center continues to develop cost-saving initiatives that still meet the needs of its customers. The goal of this research is to determine the historical utilization of airlift for retrograde operations and the effects on the inter-theater airlift system if any additional cargo hauling capacity is utilized on depositioning C-5 and C-17 assets.

Research Goals

- Determine the amount of available airlift flowing back to CONUS from Afghanistan and Iraq.
- Compare the cost of flying C-17s and C-5s back to CONUS empty vs. flying them back with full cargo loads.
- Compare the increased cost of fully laden C-17s and C-5s to the cost of using sealift to ship cargo to CONUS.
- Deliver to USTRANSCOM and AMC leadership a method for determining the cost and benefit of utilizing excess cargo capacity flowing back to the CONUS.

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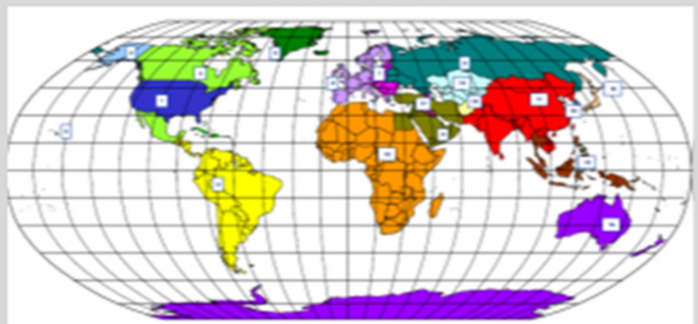
General Framework



MDS	Route	GATES Avg Used (lbs)	GDSS Avg Used (lbs)	Decision Weight (lbs)	GATES Difference	GDSS Difference
C-17	Afghanistan to Germany to Dover	15,168.9	14,106.1	25,355.9	(10,186.96)	(11,249.76)
	Iraq to Germany to Dover	19,171.2	17,058.4	11,654.7	7,516.47	5,403.67
C-5	Afghanistan to Spain to Dover	16,672.5	30,511.7	19,197.9	(2,525.39)	11,313.81
	Iraq to Spain to Dover	45,354.2	45,468.0	8,930.5	36,423.69	36,537.49

*GDSS Data: Nov 2009 to Oct 2011 and GATES Data: May 2010 to May 2011

Application – Decision Points

MDS	Route	Decision Weight (lbs)
C-17	Afghanistan to Germany to Dover	25,355.86
	Iraq to Germany to Dover	11,654.73
C-5	Afghanistan to Spain to Dover	19,197.89
	Iraq to Spain to Dover	8,930.51

**Based on assumptions in the accompanying report with the same title (ref ID AFIT/IMO/ENS/12-06), above these weights, cargo should be shipped versus flown.

Motivation

With the DOD facing more budget constraints, the cost-efficient use of airlift cargo capacity as compared to sealift could generate cost savings.

Impacts/Contributions

This research found there is still a significant amount available airlift on C-17 and C-5 aircraft. However, it shows loading additional weight on these aircraft is often not the right answer with regards to cost efficiency. When time is not a factor for the movement of the cargo, it is very difficult to overcome the cost differentials between air and sea transportation.

Collaboration: AMC/A9/AA9

Vita

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14. ABSTRACT

U.S. Transportation Command (USTRANSCOM), the Department of Defense's (DOD) Distribution Process Owner (DPO), coordinates the movement of cargo to and from the Afghanistan and Iraq Areas of Operations (AORs). It attempts to optimize movement through the use of airlift, rail, trucking, and sealift while balancing cost and timeline requirements. Past Government Accounting Office (GAO) studies have found underutilization of airlift capacity as an area to gain more value in the movement of cargo, especially opportune cargo. This research attempts to determine the current utilization rate of airlift departing the AORs and the decisions points for using sealift over available airlift capacity.

All C-17 and C-5 flights departing the AOR were analyzed to determine utilization rates with regards to capacity. Then, the additional costs of utilizing this capacity were determined as compared to sealift options to derive decision points.

The results show a continued underutilization of airlift capacity on C-17 and C-5 aircraft departing the AOR. However, when time is not a critical factor, the carrying costs involved in loading the additional cargo on these flights is often counterproductive to reducing the overall transportation cost. Recommendations were made on the appropriate weights to carry on these flights to optimize transportation costs.

15. SUBJECT TERMS: Airlift Optimization, Cargo Handling, Aerial Port Operations, Sealift Utilization

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